72.0±12.9kg) who participated in a baseline biomechanical assessment upon enrollment in this investigation. An electromagnetic tracking system interfaced with a force plate was used to collect three-dimensional kinematics of the hip and knee during three trials of a jump-landing task. Following the baseline biomechanical assessment, participants were followed prospectively through a closed healthcare system for a maximum of four years to identify those diagnosed with PFP. Incident cases of PFP were initially identified through electronic injury surveillance systems specific to the study population and determined by a manual review of medical records. The inclusion criteria for the incident PFP group included: retropatellar knee pain with physical activity, pain on palpation of either the patellar facets or femoral condyles, and negative findings on examination for injury to the knee ligaments, menisci, bursae, and synovial plica. Sagittal, frontal, and transverse plane hip and knee kinematics during the jump-landing task at initial contact (IC) with the ground, and at the time of maximum knee flexion (approximately mid-point of the task) were included in the data analysis. Separate logistic regression analyses were performed to determine the influence of each biomechanical variable on the risk of developing PFP ($P<0.05$).

Results: Of the 4418 participants who initially enrolled in this investigation, 493 participants reported a prior history of PFP and were removed from the cohort used in the final analysis. During the follow up period, 188 participants (94 females, 94 males) were diagnosed with incident PFP. Greater knee flexion at IC (>20° vs. <20°) was associated with a reduced risk of developing PFP [Odds Ratio (OR)=0.69, 95% Confidence Interval (CI)=0.49,0.99]. Less hip abduction at IC (<10° vs. >10°) was associated with an increased risk of developing PFP (OR=1.72, 95% CI=1.17, 2.51). No other kinematic variables were associated with the development of PFP ($P>0.05$).

Conclusions: Sagittal plane kinematics at the knee along with frontal plane kinematics at the hip appear to have a significant influence on the risk of developing PFP. These movement characteristics may be altered through movement retraining programs focused on primary injury prevention. These programs should focus on greater knee flexion and a wider stance during jumping and landing activities. Additional research is needed to determine if injury prevention programs are effective in reducing the incidence of PFP and the subsequent risk of injury related KOA.

63
IN VIVO CALCIUM IMAGING OF KNEE-INNERVATING DORSAL ROOT GANGLION NEURONS REVEALS INCREASED NEURONAL RESPONSIVENESS TO PHYSICAL STIMULI AFTER DMM SURGERY

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Purpose: Osteoarthritis pain is typically brought on by movement, yet there are limited techniques for studying the ability of specific movements to activate neurons. Our previous work has shown that after destabilization of the medial meniscus (DMM), mice develop slowly progressive joint damage concurrent with the following pain-related behaviors: hindpaw mechanical allodynia, knee hyperalgesia and locomotive deficits.

In vivo electrophysiology enables monitoring of action potentials in single neurons while physical stimuli are applied to the knee, but a technique to visualize concerted responses of neurons within the dorsal root ganglion (DRG) has not been available. Here, we utilized a new method for imaging intracellular calcium ((Ca)i) responses by DRG neurons in vivo, while physical stimuli are applied to the hindlimb, in order to determine how neuronal responses change after DMM surgery.

Methods: DMM (n=4) or sham (n=2) surgery was performed in 10-week old male, heterozygous Pirt-GCaMP3 mice on a C57BL/6 background. These mice express the fluorescent calcium indicator, GCaMP3, in ~90% of all sensory DRG neurons, and not in other peripheral or central tissues, through the Pirt promoter. Eight weeks after surgery, mice were deeply anesthetized using sodium pentobarbital, and the back and operated knee were shaved. A laminectomy from vertebrae L2-L6 was performed, and the L4 DRG exposed. The mouse was positioned under a Leica LSI confocal and camera system by clamping the spinal column at L2 and L6 using forceps attached to micromanipulators. Anesthesia was maintained using isofluorane during imaging and temperature was maintained using a homeothermic blanket system. Physical stimuli to the ipsilateral limb included: 1. A 100g force was applied to the hindpaw using a calibrated forceps system (IITC Rodent Pincher); 2. A 30g force was applied to the knee using the same calibrated forceps system; 3. A noxious rotation (~60°, which is beyond the normal physiological range) was applied to the knee. For each stimulus, imaging was started one minute prior to the application of the stimulus, continued while the stimulus was applied, and was stopped one minute after the stimulus was discontinued. Each 200 frame video was analyzed for numbers of neurons responding during the applied stimulus. It was assumed that similar total numbers of neurons were imaged during each experiment. At the end of each experiment, mice were sacrificed to ascertain that these mice developed similar joint damage as wild-type C57BL/6 mice.

Table 1
Number of DRG neurons responding to physical stimuli at 8 weeks post surgery. mean±SEM

	100g paw pinch	30g knee pinch	60° knee twist
Sham (n=2)	1.0±0.0	5.5±2.5	7.0±5.0
DMM (n=4)	8.8±2.3	31.6±22.1	20.8±4.1

Results: Eight weeks after DMM or sham surgery, we began by applying a 100g pinch to the ipsilateral hindpaw. This stimulus induced (Ca)i increases in somewhat greater numbers of neurons in DMM mice compared to sham mice (Table 1).

In contrast, when forces were applied directly to the operated knee, there were clear differences in (Ca)i responses seen in DRG neurons in DMM mice compared to sham DRG neurons. More neurons responded to a 30g pinch, as well as to a noxious (60°) twist applied to the operated knee in DMM mice, compared to sham mice (Table 1).

Conclusions: In this pilot experiment, we demonstrated that DRG neurons in mice that have undergone DMM surgery are more responsive to physical stimuli directed toward the operated knee compared to sham mice, matching well with pain-related behaviors. It is likely that increased (Ca)i reflects increased excitability of this neuronal population. Future work will be directed at using this technique to identify which subsets of neurons respond to these stimuli and to monitor how these neuronal responses change longitudinally over the course of the DMM model.

64
RELATION OF SMOKING TO WIDESPREAD PAIN, KNEE PAIN SEVERITY, AND PAIN SENSITIZATION: THE MULTICENTER OSTEOARTHRITIS (MOST) STUDY

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Purpose: Smokers have been reported to have more musculoskeletal pain compared with nonsmokers. Whether this is the case for knee osteoarthritis (OA) pain or rather widespread pain is not known, and, if present, the mechanism of increased pain among smokers is not clear. Pain sensitization among smokers might explain their increased risk of musculoskeletal pain. We used data from the Multicenter Osteoarthritis (MOST) Study to examine the relation of smoking to widespread pain, knee pain severity, and pain sensitization.

Methods: The MOST Study recruited 3,026 subjects with or at risk for knee OA at baseline. Cigarette smoking status (never, former, current smoker), smoking intensity (in pack-years), knee-specific WOMAC pain subscale, and pain, aching, or stiffness of each joint on most days marked on a joint pain homunculus were asked at baseline and the 84-month visit. Widespread pain (WSP) was defined using ACR criteria. Incident WSP was defined as development of WSP during 84-month follow-up among subjects without WSP at baseline. Pain sensitization was examined at the 84 month visit. Knee pain severity was assessed with the knee-specific WOMAC pain subscale. Temporal summation (TS) at the right wrist was measured by application of a 60g von Frey monofilament repeatedly (30 x1Hz), and defined as being present if there was an increase in pain rating at the end of the train. Pressure pain threshold (PPT) at the right wrist was measured using a pressure algometer applied with steadily increasing pressure and recordings were taken at the first sensation of slight pain. We